

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 9 of 20

REMARKS

Pending Claims:

Claims 1-50 are currently pending in the present application. Claims 1, 6, 7, 20, 34, and 40 are amended by the present Amendment. Claims 41-50 are added by the present Amendment. No new matter is added by these amendments. Upon entry of the present Amendment, reconsideration of claims 1-40 and consideration of new claims 41-50 is respectfully requested.

Rejections under 35 U.S.C. §102(b) As Being Anticipated by Kouznetsov:

Claims 1, 5-10, 13, 14, 16, 19, 20, 22-31, 34, 37, 38, and 40 are rejected under 35 U.S.C. §102(b) as being anticipated by Kouznetsov (WO98/40532) (hereinafter "Kouznetsov"). Independent claims 1, 7, 20 and 40 are herein amended to more clearly recite the invention. No new matter is added by these amendments.

To anticipate a claim under 35 U.S.C. §102, a single reference must teach every aspect of the claimed invention either explicitly or impliedly. Any feature not directly taught by the reference must be inherently present in the reference. Thus, a claim is anticipated by a reference only if each and every element of the claim is described, either expressly or inherently, in a single prior art reference.

Independent Claim 1 and Dependent Claims 5-10, 13, 14, 16, and 19

The Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 1 as currently amended. Independent claim 1 has been amended to recite a magnetically enhanced sputtering source having a power supply that generates a voltage pulse that produces an electric field between an anode and a cathode assembly. An amplitude and a rise time of the voltage pulse is chosen to increase the excitation rate of ground state atoms that are present in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms in the weakly-ionized plasma. This amendment is supported by the originally-filed specification of the present application. See, for example, paragraphs 59-

Amendment and Response

Applicant: Chistyakov

Serial No.: 10/065,277

Page 10 of 20

69 of the originally-filed specification. The Applicant submits that no new matter is added by the amendments to independent claim 1.

The Applicant believes that there is no description in Kouznetsov of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase an excitation rate of ground state atoms that are present in a weakly-ionized plasma to generate a multi-step ionization process. Instead, the Applicant believes that the pulsed power source described in Kouznetsov generates a gas having a fully ionized state using a single-step ionization process. According to Kouznetsov, the pulsed power source used in his apparatus provides "pulses in such a way, i.e. that so much power is developed in each pulse, that in the application of such a pulse, for a very short time during the start of the pulse, the state of the gas located at the region in which the electrons are trapped by the magnetic field will very rapidly reach a fully ionized state..." See, for example, Kouznetsov page 5, lines 1-4. The application of a very large voltage pulse (2,000 Volts) having a fast rise time appears to fully ionize the gas by direct ionization from electrons located in the region having crossed electric and magnetic fields. See, for example, Kouznetsov page 12, lines 22-26.

The Applicant respectfully submits that there is no description in Kouznetsov of a power supply that generates a voltage pulse which creates a multi-step ionization process that includes generating excited atoms from ground state atoms that are present in the weakly ionized plasma, and then ionizing the excited atoms in the weakly-ionized plasma as claimed in amended claim 1. Instead, the Applicant believes that the ionization process described in Kouznetsov is a single-step ionization process known as direct ionization by electron impact.

In view of the above remarks, the Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 1 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Kouznetsov does not anticipate independent claim 1 as currently amended under 35 U.S.C. §102(b). Thus, the Applicant submits that independent claim 1 as currently amended is allowable. The Applicant also submits that dependent claims 5-10, 13, 14, 16, and 19 are allowable as depending from an allowable base claim.

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 11 of 20

Independent Claim 20 and Dependent Claims 22-31, 34, 37, and 38

The Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 20 as currently amended. Independent claim 20 is herein amended to recite the step of applying a voltage pulse to the weakly-ionized plasma. An amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process generates excited atoms from ground state atoms in the weakly-ionized plasma, and then ionizes the excited atoms in the weakly-ionized plasma. This amendment is supported by the originally-filed specification of the present application. See, for example, paragraph 59-69 of the originally-filed specification. No new matter is added by the amendments to independent claim 20.

The Applicant believes that there is no description in Kouznetsov of a method of generating a strongly-ionized plasma using a multi-step ionization process as claimed in amended claim 20. Instead, as previously discussed, the Applicant believes that Kouznetsov describes a single-step ionization process whereby the application of a very large voltage pulse having a fast rise time creates a gas having a fully ionized state (See page 12, lines 22-26). The Applicant believes that the large voltage pulse described in Kouznetsov ionizes the gas by direct ionization from electrons located in the region of crossed electric and magnetic fields.

In view of the above remarks, the Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 20 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Kouznetsov does not anticipate independent claim 20 as currently amended. Thus, the Applicant submits that amended independent claim 20 and dependent claims 22-31, 34, 37, and 38 are allowable under 35 U.S.C. §102(b).

Rejections under 35 U.S.C. §102(b) as Being Anticipated by Mozgrin:

Claims 1, 4, 5, 7, 13, 14, 16, 19-25, 27-29, 32, 33, 37, and 40 are rejected under 35 U.S.C. §102(b) as being anticipated by Mozgrin et al. entitled "High Current Low-Pressure Quasi-Stationary Discharge in a Magnetic Field: Experimental Research", Plasma Physics

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 12 of 20

Reports, Vol. 21, No. 5, 1995, pp. 400-409 (hereinafter "Mozgrin"). Independent claims 1, 20 and 40 are herein amended to more clearly recite the invention. No new matter is added by these amendments.

To anticipate a claim under 35 U.S.C. §102, a single reference must teach every aspect of the claimed invention either explicitly or impliedly. Any feature not directly taught by the reference must be inherently present in the reference. Thus, a claim is anticipated by a reference only if each and every element of the claim is described, either expressly or inherently, in a single prior art reference.

Independent Claim 1 and Dependent Claims 4, 5, 7, 13, 14, 16, and 19

The Applicant respectfully submits that Mozgrin does not describe each and every element of independent claim 1 as currently amended. Independent claim 1 has been amended to recite a power supply generating a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process generates a strongly-ionized plasma from the weakly-ionized plasma by first exciting ground state atoms to generate excited atoms, and then by ionizing the excited atoms in the weakly-ionized plasma. This amendment is supported by the originally-filed specification of the present application. See, for example, paragraphs 59-69 of the originally-filed specification. The Applicant submits that no new matter is added by the amendments to independent claim 1.

The Applicant believes that there is no description in Mozgrin of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase the excitation rate of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. Instead, the Applicant believes that Mozgrin describes a pulsed discharge supply unit that generates a plasma with a prior art direct ionization process using very high-power pulses.

The Applicant believes that the quasi-stationary discharge described in Mozgrin is formed with a prior art ionization process known as direct ionization by electron impact and

Amendment and Response

Applicant: Chistyakov

Serial No.: 10/065,277

Page 13 of 20

does not use the multi-step ionization process of the present invention. For example, the current and voltage characteristics (CVC) shown in FIG. 4 of Mozgrin indicate to the Applicant that the quasi-stationary discharge described in Mozgrin is formed by direct ionization. The CVC shown in FIG. 4 of Mozgrin includes four parts.

Part 1 of the CVC shown in FIG. 4 of Mozgrin is a low current (0.2A) discharge regime that is a pre-ionization stage of the quasi-stationary discharge. The pre-ionization stage is generated using a high-voltage power supply unit that produces a high-voltage, low-current discharge between two electrodes to create a pre-ionized plasma. The pre-ionized plasma includes ions that are generated by a typical direct ionization process.

Part 2 of the CVC shown in FIG. 4 of Mozgrin is a high-current, high-voltage discharge regime having a discharge current that is in the range of 0.2A-15A and a discharge voltage that is in the range of 350V-500V. The plasma discharge appears to be a typical magnetron plasma discharge that is commonly generated in plasma processing systems. The plasma discharge is formed by using a square voltage pulse. There is no description in Mozgrin related to Part 2 of the CVC of choosing an amplitude and a rise time of the voltage pulse in order to increase a rate of excitation of ground state atoms to create excited atoms in a multi-step ionization process as claimed in amended independent claim 1. In fact, there is no description in Mozgrin of choosing an amplitude and a rise time of a voltage pulse to change the plasma discharge conditions. Mozgrin describes varying the plasma discharge conditions by changing the pressure and magnetic field strength, but does not mention varying the plasma discharge conditions by changing the amplitude and the rise time of the voltage pulse. See Mozgrin page 403 lines 8-13.

Part 3 of the CVC shown in FIG. 4 of Mozgrin is a high-current discharge regime in which the discharge voltage remains stationary at 90V over a current that is in the range of 15A-1,000A. Part 3 of the CVC corresponds to a prior art magnetron discharge for high-pressure (10^{-1} torr) plasma processing. The voltage drops sharply in this regime until the current reaches a quasi-stationary value that maintains the discharge power at a constant value. There is no description related to Part 3 of the CVC of choosing an amplitude and a

Amendment and Response

Applicant: Chistyakov

Serial No.: 10/065,277

Page 14 of 20

rise time of a voltage pulse to increase a rate of excitation of ground state atoms to create excited atoms in a multi-step ionization process as claimed in amended independent claim 1.

Part 4 of the CVC shown in FIG. 4 of Mozgrin is a high-current, low-voltage arc discharge regime having a current that is greater than 1kA and a voltage that is in the range of 10-30V. Arc discharges are generally undesirable for most plasma processing applications. Arc discharges are observed in conventional magnetrons when too much power applied to the plasma. There is no description related to Part 4 of the CVC of choosing an amplitude and a rise time of a voltage pulse to increase a rate of excitation of ground state atoms to create excited atoms in a multi-step ionization process as claimed in amended independent claim 1.

Thus, the Applicant submits that there is no teaching or suggestion of increasing an excitation rate of ground state atoms in a weakly-ionized plasma to generate a multi-step ionization process in either Part 1, Part 2, Part 3, or Part 4 of the CVC of Mozgrin. In view of the above remarks, the Applicant respectfully submits that Mozgrin does not describe each and every element of independent claim 1 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Mozgrin does not anticipate independent claim 1 as currently amended. Thus, the Applicant submits that amended independent claim 1 and dependent claims 4, 5, 7, 13, 14, 16, and 19 are allowable under 35 U.S.C. §102(b).

Independent Claim 20 and Dependent Claims 21-25, 27-29, 32, 33, and 37

The Applicant believes that Mozgrin does not describe each and every element of independent claim 20 as currently amended. Independent claim 20 is herein amended to recite the step of applying a voltage pulse to the weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter target material from the sputtering target.

The Applicant respectfully submits that there is no description in Mozgrin of applying a

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 15 of 20

voltage pulse to a weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process as claimed in amended claim 20. In view of the above remarks, the Applicant respectfully submits that Mozgrin does not describe each and every element of independent claim 20 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Mozgrin does not anticipate amended independent claim 20 and dependent claims 21-25, 27-29, 32, 33, and 37 under 35 U.S.C. §102(b). Thus, the Applicant submits that amended independent claim 20 and dependent claims 21-25, 27-29, 32, 33, and 37 are allowable.

Rejections under 35 U.S.C. §103(a) As Being Unpatentable Over Kouznetsov:

Claims 1-3 are rejected under 35 U.S.C. §103(a), as being unpatentable over Kouznetsov. The Office Action states that Kouznetsov discloses substantially all of the features of the claimed invention except that the constant power and the constant voltage are not discussed. The Office Action further states that the constant power and constant voltage are provided by the power supply in the crossed E and B field region since the power and the voltage must be constant during this period to produce a state of full ionization. The Office Action concludes that it would have been obvious to have utilized constant power and voltage as taught by Kouznetsov because it allows for producing a state of full ionization.

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. The Applicant submits that there is no teaching or suggestion in Kouznetsov of such a power supply. In fact, there is no mention of excited atoms in the Kouznetsov reference. Instead, the Applicant believes that the Kouznetsov reference describes a process for transitioning a gas to an ionized state using a single-step ionization process in a conventional magnetron sputtering device (See page 5, lines 20-26). The process described in the Kouznetsov reference appears to use direct ionization to transition a gas from a state of glow discharge, to a state of arc discharge, and finally to a fully ionized state (See page 5, lines 6-8).

Amendment and Response

Applicant: Chistyakov

Serial No.: 10/065,277

Page 16 of 20

According to Kouznetsov, this fully ionized state is realized with a "rather high, substantially constant voltage when the gas is in the highly ionized state of crossing electric and magnetic fields, as long as the input voltage is sufficient to sustain this state." (See Kouznetsov page 5, lines 33-35). The Applicant believes that there is no teaching or suggestion in Kouznetsov of a power supply that generates a voltage pulse that creates a multi-step ionization process.

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) in view of the Kouznetsov reference. The Applicant also submits that dependent claims 2-3 are allowable as depending from an allowable base claim.

Rejections under 35 U.S.C. §103(a) As Being Unpatentable Over Mozgrin:

Claims 1-3, 17, 20, and 39 are rejected under 35 U.S.C. §103(a), as being unpatentable over Mozgrin. The Office Action states that Mozgrin discloses substantially all features of the claimed invention except that the constant power, constant voltage, and the ionization source being a UV source, an X-ray source, an electron beam source and an ion beam source are not discussed. The Office Action further states that the constant power and constant voltage are provided at the height of the square waveform to produce a plasma density higher than the pre-ionization plasma density. The Office Action concludes that it would have been obvious to have utilized constant power and voltage because it allows for production of a higher density of plasma than during the pre-ionization.

Independent Claim 1 and Dependent Claims 2-3 and 17

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process.

The Applicant submits that there is no teaching or suggestion in Mozgrin of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase an excitation rate of ground state atoms in a weakly-ionized plasma to generate a multi-

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 17 of 20

step ionization process. Instead, as previously described herein, the Applicant submits that Mozgrin describes a method for generating a plasma using a direct ionization by electron impact (See page 402, col. 2, lines 13-48 to page 403, col. 1, lines 1-13).

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) in view of the Mozgrin reference. The Applicant also submits that dependent claims 2-3 and 17 are allowable as depending from an allowable base claim.

Independent Claim 20 and Dependent Claim 39

Independent claim 20 has been amended to recite the step of applying a voltage pulse to the weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter target material from the sputtering target.

The Applicant submits that there is no teaching or suggestion in Mozgrin of applying a voltage pulse to a weakly-ionized plasma where the voltage pulse has an amplitude and a rise time that are chosen to increase an excitation rate of ground state atoms in a weakly-ionized plasma to generate a multi-step ionization process. Instead, the Applicant submits that Mozgrin describes a method for generating a plasma using direct ionization by electron impact. There is simply no teaching or suggestion in Mozgrin of choosing an amplitude and a rise time of a voltage pulse to increase an excitation rate of ground state atoms in a weakly-ionized plasma.

In view of the above remarks, the Applicant submits that amended independent claim 20 is not obvious under 35 U.S.C. §103(a) in view of the Mozgrin reference. The Applicant also submits that dependent claim 39 is allowable as depending from an allowable base claim.

Rejections under 35 U.S.C. §103(a) Over Kouznetsov In view of Chiang:

Claims 1, 10-12, 15, 20, and 34-36 are rejected under 35 U.S.C. §103(a), as being unpatentable over Kouznetsov in view of U.S. Patent No. 6,398,929 to Chiang et al. (hereinafter

Amendment and Response

Applicant: Chistyakov

Serial No.: 10/065,277

Page 18 of 20

"Chiang"). The Office Action states that Kouznetsov discloses substantially all features of the claimed invention except that the temperature control of the substrate is not discussed, biasing the substrate is not discussed, and applying DC power to the target is not discussed. The Office Action further states that Chiang describes supplying cooling gas to the backside of the wafer, biasing the wafer holder, and biasing the target with a DC power supply.

Independent Claim 1 and Dependent Claims 10-12 and 15

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process.

The Applicant submits that there is no teaching or suggestion in Kouznetsov of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. There is no mention of exciting ground state atoms in the Kouznetsov reference. Instead, the Applicant believes that the Kouznetsov reference describes a process for transitioning a gas to an ionized state using a single-step ionization process in a conventional magnetron sputtering device (See page 5, lines 20-26). The process described in the Kouznetsov reference appears to use direct ionization to transition a gas from a state of glow discharge, to a state of arc discharge, and finally to a fully ionized state (See page 5, lines 6-8).

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) over Kouznetsov in view of Chiang. The Applicant also submits that dependent claims 10-12 and 15 are allowable as depending from an allowable base claim.

Independent Claim 20 and Dependent Claims 34-36

Independent claim 20 has been amended to recite the step of applying a voltage pulse to the weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 19 of 20

step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter target material from the sputtering target.

The Applicant submits that there is no teaching or suggestion in Kouznetsov of applying a voltage pulse to a weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. Instead the Applicant believes that Kouznetsov teaches a single-step ionization process whereby the application of a very large voltage pulse having a fast rise time creates a gas having a fully ionized state (See page 12, lines 22-26). The Applicant believes that the large voltage pulse described in Kouznetsov ionizes the gas by direct ionization from electrons located in the region of crossed electric and magnetic fields.

In view of the above remarks, the Applicant submits that amended independent claim 20 is not obvious under 35 U.S.C. §103(a) over Kouznetsov in view of Chiang. The Applicant also submits that dependent claims 34-36 are allowable as depending from an allowable base claim.

Rejections under 35 U.S.C. §103(a) Over Kouznetsov in view of Kadlec:

Claims 1 and 18 are rejected under 35 U.S.C. §103(a), as being unpatentable over Kouznetsov in view of Kadlec et al. (WO95/04368) (hereinafter "Kadlec"). The Office Action states that Kouznetsov discloses substantially all features of the claimed invention except that the use of an electromagnet is not disclosed. The Office Action further states that Kadlec suggests the use of electromagnets for sputtering.

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. As previously discussed, the Applicant submits that there is no teaching or suggestion in Kouznetsov of such a power supply and there is no mention of exciting ground atoms in the Kouznetsov reference.

Amendment and Response
Applicant: Chistyakov
Serial No.: 10/065,277
Page 20 of 20

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) over Kouznetsov in view of Kadlec. The Applicant also submits that dependent claim 18 is allowable as depending from an allowable base claim.

New Claims 41-50:

The Applicant submits that independent claim 1 is allowable as currently amended. The Applicant also submits that dependent claims 41-45 are allowable as depending from an allowable base claim. In addition, the Applicant submits that independent claim 20 is allowable as currently amended and dependent claims 46-50 are also allowable as depending from an allowable base claim.

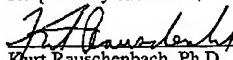
CONCLUSION

Claims 1-50 are currently pending in the present application. Claims 1, 6, 7, 20, 34, and 40 are amended by the present Amendment. Claims 41-50 are added by the present Amendment. In view of the foregoing, reconsideration and allowance of all pending claims (i.e., claims 1-50) is respectfully requested.

The Commissioner is hereby authorized to charge the extension fee, the additional claims fee, and any other proper fees to Attorney's Deposit Account No. 501211.

If, in the Examiner's opinion, a telephonic interview would expedite prosecution of the present application, the undersigned attorney would welcome the opportunity to discuss any outstanding issues, and to work with the Examiner toward placing the application in condition for allowance.

Respectfully submitted,


Kurt Rauschenbach, Ph.D.
Attorney for Applicant
Rauschenbach Patent Law Group, LLC
Post Office Box 387
Bedford, MA 01730

Date: June 14, 2004
Reg. No. 40,137

Tel. No.: (781) 271-1503
Fax No.: (781) 271-1527